SH-2/SH-DSP
Embedded RISC MCU Family

High-Performance, Low-Cost 32-Bit Microcontrollers

SuperH®
RISC engine

HITACHI
Inspire the Next

Hitachi's SH-2 product family comprises two series of high-performance, low-cost 32-bit devices based on the SuperH architecture: SH-2 series RISC microcontrollers (MCUs) and SH-DSP series RISC/DSP processors.

■ Description

SH-2 encompasses a diverse range of upward-code-compatible devices. The SH-2 MCUs have high performance (up to 65MIPS at 50MHz) and offer low power consumption. They provide great functionality through a rich set of on-chip integrated peripherals, including timers that simplify motor-control and industrial equipment designs.

One MCU in the SH-2 series, the SH7047F, has 256KB of flash, one CAN 2.0B port, three SCI channels and several 16-bit timers, making it an *ideal choice for 3-phase DC brushless motor control applications.*
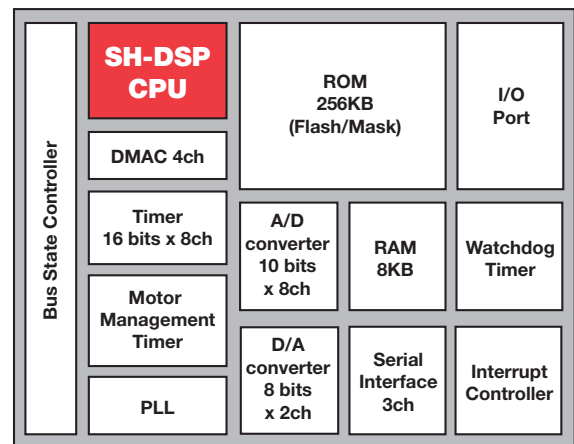
The processors in the SH-DSP series combine into a single core an SH-2 32-bit RISC CPU and a full-featured, 16-bit integer DSP unit that can execute 16x16 integer multiplies in a single cycle. The RISC/DSP core multi-tasks its operations to deliver up to 78MIPS or 120MOPS at 60MHz.

One member of the SH-DSP series, the SH7065, integrates 256KB of on-chip flash, and is a good choice for high-performance systems and precision motor control applications.

■ Development Tools

A complete set of proven hardware and software development tools is available from Hitachi and third-party suppliers to speed up the system design and debug

Block Diagram of SH7065 (SH-DSP)

SH-DSP CPU	**ROM 256KB (Flash/Mask)**	**I/O Port**
DMAC 4ch		
Timer 16 bits x 8ch	**A/D converter 10 bits x 8ch**	**RAM 8KB**	**Watchdog Timer**
Motor Management Timer			
PLL	**D/A converter 8 bits x 2ch**	**Serial Interface 3ch**	**Interrupt Controller**

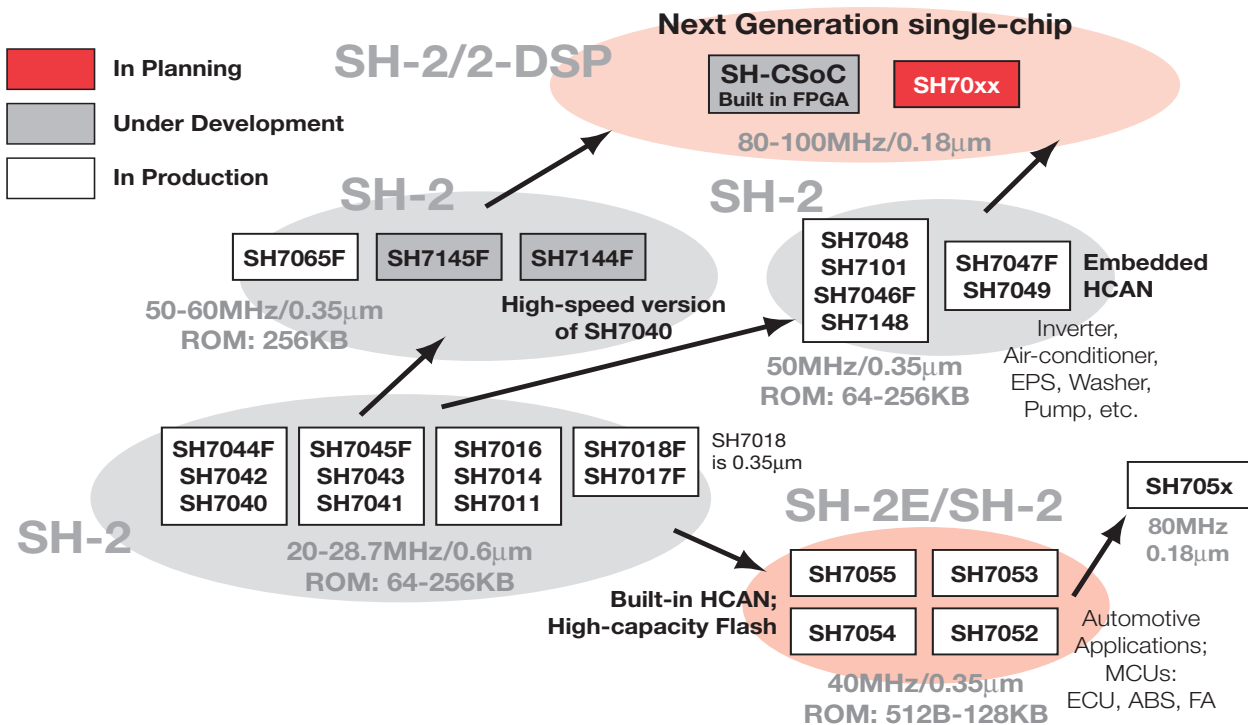(Bus State Controller — left vertical label)

process. These tools include evaluation kits, emulators, companion chips, reference design platforms, software board support, real-time operating system, middleware, and application support.

■ Technology Roadmap (see next page)

To protect customers' engineering investments and meet changing device needs in evolving embedded system markets, Hitachi has a solid technology roadmap for the SuperH product family, including the SH-2 family. New chips now planned will fit high-performance applications that require digital image processing as well as mechanical control on a single chip. They will offer design flexibility and field programmability. Devices built on 0.18-micron process technology will offer over 100 MIPS performance and combine large memory and embedded FPGA solutions on one chip.

Shaping intelligence

SH-2/SH-DSP Embedded RISC Family

SH-2/SH-DSP MCU Roadmap

Legend:
- In Planning
- Under Development
- In Production

Next Generation single-chip

SH-2/2-DSP

SH-CSoC Built in FPGA | SH70xx
80-100MHz/0.18μm

SH-2
SH7065F | SH7145F | SH7144F
50-60MHz/0.35μm
ROM: 256KB
High-speed version of SH7040

SH-2
SH7048 / SH7101 / SH7046F / SH7148 | SH7047F / SH7049 — Embedded HCAN
Inverter, Air-conditioner, EPS, Washer, Pump, etc.
50MHz/0.35μm
ROM: 64-256KB

SH-2
SH7044F / SH7042 / SH7040 | SH7045F / SH7043 / SH7041 | SH7016 / SH7014 / SH7011 | SH7018F / SH7017F
SH7018 is 0.35μm
20-28.7MHz/0.6μm
ROM: 64-256KB

Built-in HCAN; High-capacity Flash

SH-2E/SH-2
SH7055 | SH7053
SH7054 | SH7052
40MHz/0.35μm
ROM: 512B-128KB

SH705x
80MHz 0.18μm
Automotive Applications; MCUs: ECU, ABS, FA

■ High-performance CPU

- SH-2 RISC core: Up to 65MIPS at 50MHz
- SH-DSP RISC/DSP core: Up to 78MIPS at 60 MHz
- Upward code compatible with SH-1 series
- Load-store architecture
- Instruction length: Fixed 16-bit length for improved code efficiency
- Delayed unconditional branch instructions to reduce pipeline disruption
- Instruction execution: one instruction per clock cycle
- 5 stage instruction pipeline
- Sixteen 32-bit general-purpose registers and four control and nine bank registers for fast jumps and interrupt response
- Built in hardware multiply accumulate unit (32-bit x 32-bit + 64-bit)

■ Full-featured 16-bit integer DSP capability (SH-DSP)

- Extended Harvard architecture: accesses one instruction and two data words per cycle
- Executes four independent operations in parallel
- Single-cycle 16x16 multiply operations; two-cycle 16x16+64 MAC operations
- Zero overhead looping, circular buffer, saturation arithmetic, guard bits
- Any DSP operation can be performed in parallel with two memory accesses

■ High-capacity on-chip memory

- Up to 512 KB of on-chip single-voltage programmable flash
- 8/16/32-bit external bus (not all SH-2 devices have 32-bit bus) Data bus support

■ High peripheral integration

- Bus state controller: Direct connection to DRAM, SRAM, and Flash
- DMAC: Single- and dual-address modes
- Multifunction timer units: Several 16-Bit timers, input capture, output compare, PWM generator
- A/D converter: 10-bit, 8 input channels, (12 channels for SH7046; 16 channels for SH7047)

- Serial communications interface: configurable for synchronous or asynchronous operation.

- MAC: 32 x 32 + 64 ➜ 64 Multiply accumulate function

- Other peripherals (varies by device): cache, Data Transfer Controller, clock pulse generator, I²C, interrupt controller, compare-match timer, WDT, FPU, CAN controller, user break controller

- Up to 106 I/O pins

■ **Flexible power management**

- Three power down modes to lower power consumption

- Clock gearing enables clock to be changed "on the fly"

■ **On-chip hardware support for debugging**

- Use for "Debugging in the System"

- Allows low-cost S/W debugging

- No real-time in-circuit emulator required

- Single step provides convenient means of debugging in ROM

- User break creates interrupt request at specific location/area (Interrupt service routine required for support to analyze program status and to restart program under test)

- On-chip debugger is compatible with JTAG specifications.

■ **Hardware development tools**

Emulators:
Hitachi (E10A, E6000, E8000S), Sophia, Lauderbach, Yokogawa

Evaluation boards: Hitachi (EDKs)

Sockets: Yamaichi, Tokyo Electec

PROM/flash programmers:
Data I/O, BP Microsystems

■ **Software**

Project builders, C, C++ compilers, assemblers, simulator/debuggers:

- Green Hills Software

- Hitachi HEW

- IAR software

- Redhat GNU Pro™

- FDT: Flash Development Toolkit

■ **Real-time operating system (RTOS) products**

- ATI (Nucleus+)

- Linux

- CMX (CMX-RTX)

- SuperTask

- ThreadX

- Wind River (VxWorks)

■ **Application support**

- **Middleware:**
Analogical Systems, Extended Systems

- **Co-verification tools:**
Hitachi IBIS Simulation Models, Mentor

■ **Third-party vendors with SuperH software driver support**

- **Graphic chips:**
TVIA CyberPro 5xxx Series Epsen (SED135x, SED137x)

- **PCI:** Quicklogic

- **GPS:** SiRF Technology

Typical SH-2/SH-DSP Applications			
SH-2 Series	**Key Message**	**Segment**	**Applications**
SH701x series (SH7017, SH7018)	1. Compact version of SH704x 2. Low price 3. Lower power consumption	OA & Industrial, Consumer, White goods	Motor controllers, Printer, Fax machine, DVC, Consumer appliances (cooking range, etc.)
SH7046 series (SH7046, SH7148, SH7047, SH7049)	1. Single chip control of two motors simultaneously 2. Built in 32bit high-speed CPU embedded multiplier 3. Operates with single power supply 4. Many A/D inputs 5. Embedded CAN (SH7047/9) *See Application diagram on page 5*	White goods (SH7046, SH7148) Automotive Body Systems (SH7047/9)	Air Conditioners, Pump, Washer, Power door, Seat positioning, Starter/Generator, Car air conditioner, EPS, Auto sensor, ECU
SH7144 series (SH7144, SH7145)	1. Embedded high performance multi-purpose CPU – 65MIPS performance. 2. Ideal for low power consumption systems. 3. Rich set of peripherals including I²C, four SCIs, etc. 4. Reduced A/D conversion time. 5. Makes use of SH7040 series software	Industrial, Digital Consumer	Inverter, AC Servo, Factory Automation, Robot, HDD recorder, DVD recorder, DVC, liquid crystal projector
SH-DSP series (SH7065)	1. A Unified 60MHz SH and DSP CPU engine optimized for low power and cost 2. 256kB embedded flash memory using 0.35um 3.3V single power supply 3. Peripherals (PWM Timer, A/D, DMA Controller, etc) 4. External Bus expansion up to 32 Bits	OA, Industrial and Consumer (SH7065)	AC servos, multi-function printers, industrial controller systems, medical equipment (heart monitors, etc.), seismic monitoring equipment

SH-2/SH-DSP Development Tools

HEW

- Flexible Code development environment
- Project Wizard for easy setup
- Hierarchical project support
- File dependency scanning–Non-source files can be added
- SuperH C++ Compiler toolchain
- Fully featured integrated editor
- Customizable build process and Integrated MAKE facility

SuperH HEW CD comes with:
- Hitachi Embedded Workshop (HEW)
- SuperH C/C++ Compiler and cross-assembly tool chain
- Cycle-accurate simulator
- Hitachi Debugging Interface (HDI)
- User manuals as Acrobat PDFs
- Installer

Part number: US0700PXIW2SR

HDI

- High-level graphical C source code debugging as well as assembly-level debugging
- Supports C++ debugging
- In-circuit emulation control
- Breakpoint control using point and click; Breakpoints can be set on labels
- Single stepping at the source code level (step, step over, step out)
- Source display from in-circuit emulator trace buffer
- Contents of memory, registers and symbols can be viewed and modified, such as watchpoints and customizable I/O windows.
- Generic GUI for all Hitachi debug platforms, including EDK monitors

FDT

- Supports direct connection to customer's own target
- Supports BOOT and USER modes
- Serial communication interface
- Advanced messaging levels to aid hardware development

Free download at:
http://www.hmse.com/products/fdt/index.htm

Upgrade patches to support new devices are available at:
http://www.hmse.com/products/fdt/support.htm

E10A

- PCI or PCMCIA interface
- 2 to 4 hardware breakpoints
- 256 software breakpoints available
- Stores up to 8 levels of branch instruction trace
- HDI front end user interface included

Ordering Information

E10A Emulator
Devices: SH7047, SH7144, SH7145

E10A Part Number: SH7047

PCMCIA: HS7047KCM01H (H-UDI)
          HS7047KCM02H (H-UDI and AUD)

PCI: HS7047KCI01H (H-UDI)
          HS7047KCI02H (H-UDI and AUD)

SH7144F/45F

PCMCIA: HS7144KCM01H (H-UDI)
          HS7144KCM02H (H-UDI and AUD)

PCI: HS7144KCI01H (H-UDI)
          HS7144KCI02H (H-UDI and AUD)

E6000

- Zero wait-state, real-time emulation
- 256 PC breakpoints
- Up to 12 hardware breakpoints
- 32k-cycle trace buffer
- 4 user logic probes
- Multiple target clock selection
- HDI debugger software included
- Compatible with Windows 95/98/NT/2000

Ordering Information

E6000 emulator

Device: SH7017, SH7018
E6000 part number: HS7010EPI60H

Interface board part number:
HS6000EIC02HE (PCI Board)
HS6000EIP01H (PCMCIA Card)
HS6000ELN01H (LAN Adapter)

Target Cable:
HS7017ECH61HE (FP-112: SH7017)
HS7018EWN61H (TFP-100B: SH7018)

E8000

- Provides C-level debug, code download, single stepping, breakpoints, and trace review
- Allows 26 hardware break conditions and 255 software break conditions
- High-speed, real-time emulation up to 180MHz
- Real-time trace support
- Interfaces to host PC
- Target connection

For ordering information on E8000, please contact your local sales representative or distributor, or visit:

http://semiconductor.hitachi.com/tools

EDK: Evaluation Development Kit

- Target board for SH-2 MCUs
- Built-in debug monitor
- Supports code download, memory and register editing, stepping and breakpoints.
- RS-232 serial ports (via MCU's SCI channels; one channel is required by the debug monitor)
- LEDs for power indication and user application.
- Connectors for a user interface to MCU I/O ports
- HDI front end user interface included

EDKs include
- Evaluation board with serial connection cable
- HEW with manuals (on CD-ROM)
- Evaluation version (time-limited) of Hitachi Complier
- Debugger with user manual; device data book (on CD-ROM)
- Evaluation board user manual including schematics and tutorials on how to use the tools

Ordering Information

Device:
SH7017, SH7047**, SH7145***

EDK part numbers:
US7047EDK1, EDK7145

For more information on development tools and links to Hitachi's partners websites, visit
http://semiconductor.hitachi.com/tools/

** SH7047 EDK available Q3'02
***SH7145 EDK available Q4'02

■ Application Example

SH7047 Special Features

Can control two motors simultaneously using the MTU and MMT

The SH7047 MCU has a multifunction timer pulse unit (MTU) comprising five 16-bit timer channels, with a maximum capability of 16 pulse inputs/ outputs, as well as a motor management timer (MMT) that can generate a six-phase non-overlap-time pulse-width modulation (PWM) output. Used together, the MMT and MTU enable the SH7047 to control two motors.

Implement fast, reliable communication using CAN

The SH7047F device provides a one-channel Hitachi controller area network (HCAN2) function compliant with the Bosch CAN Ver. 2.0B active specification.

The HCAN2 function features full CAN support and a 32-message buffer. It allows fast and highly reliable communication in in-vehicle automotive systems and industrial environments.

SH7047 Application: Standard Inverter System
Inverter Control on one high-performance chip
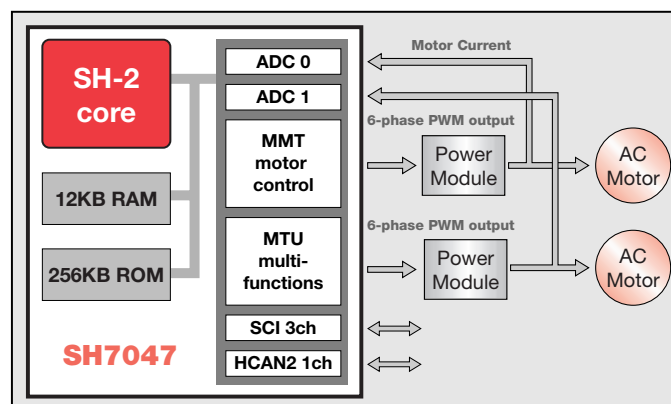
SH7046 Series provides:
- More accurate control
- Energy-efficient motor control
- Reduced mechanical and electrical motor noise
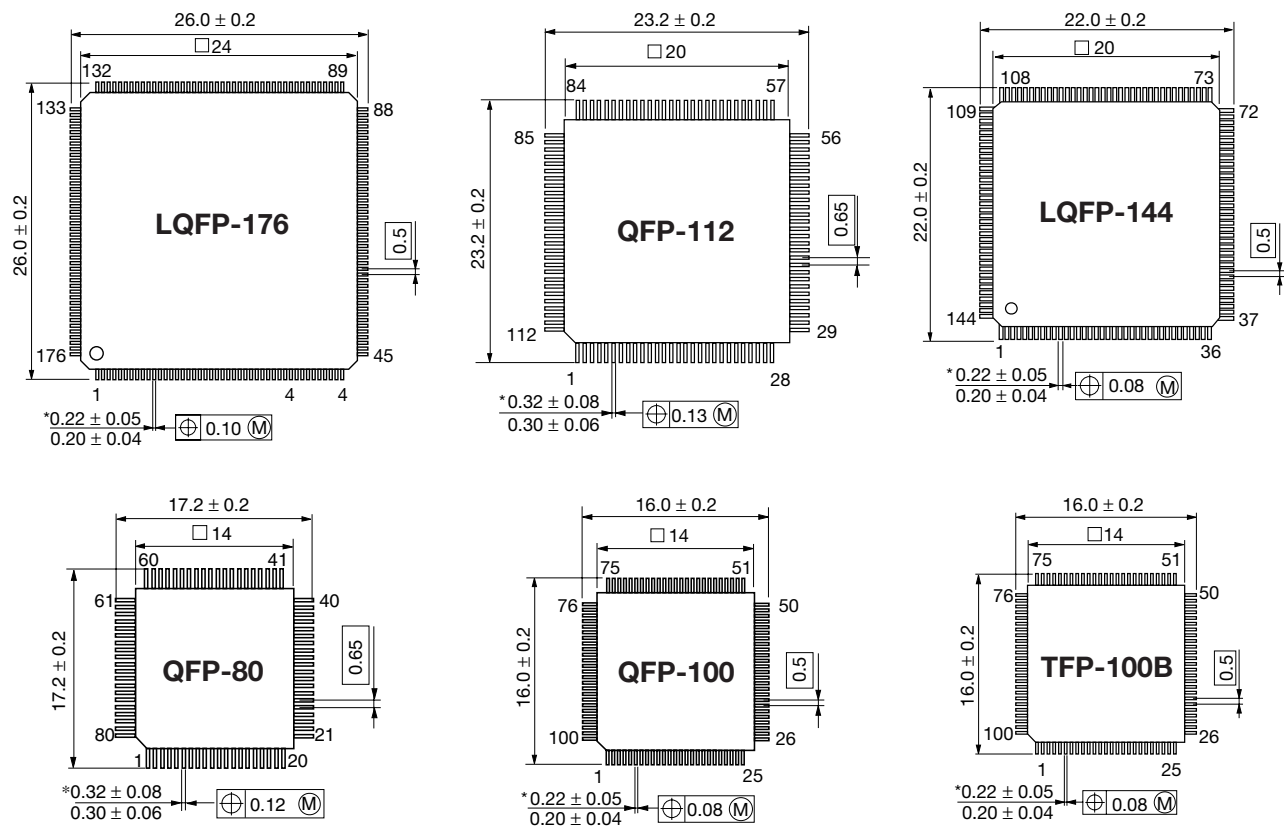- Reduced vibration
- Sensorless motor control

■ SH-2 and SH-DSP Selector Guide

Device	Part Number	ROM (KByte)/Type [1]	RAM (KByte)	Supply Voltage IO (Volts)	Frequency (MHz)	16-bit Timer [2] (channel)	DMAC	DTC [3]	SCI (Async/sync)	Other	ADC 10 bits (ch)	Internal	External	I/O port	E6000	E8000	E10A	H-UDI AUD	Temperature Range [4]	Package
SH7017	HD64F7017F28	128 F	4 (1k cache)	4.5-5.5	28.7	5	2	-	2	-	8	29	7	82	Yes	-	-	-	Std.	QFP-112
SH7018	HD64F7018X20	160 F	4	5v IO/ 3.0-3.6	20	5	-	-	1	-	12	20	8	80	-	Yes	-	-	Std.	TFP-100B
SH7047	HD64F7047F50	256 F	12	4.5-5.5	50	MTU, MMT (8)	-	Yes	3	HCAN	16	49	5	69	-	Yes	Yes	Yes	Std.	QFP-100
	HD64F7047FW40																		WTR	
	HD64F7047FJ40																		J	
	HD6437049F50	128 M	8	4.5-5.5	50	MTU, MMT (8)	-	Yes	3	HCAN	16	49	5	69	-	Yes	-	-	Std.	QFP-100
	HD6437049FW40																		WTR	
	HD6437049FJ40																		J	
SH7046	HD64F7046F50	256 F	12	4.5-5.5	50	MTU, MMT (8)	-	Yes	3	-	12	42	5	53	-	Yes	Yes	Yes	Std.	QFP-80
	HD6437148F50	64 M	4												-	Yes	-	-		
	HD6437048F50	128 M	4	4.0-5.5	50	MTU, MMT (8)	-	Yes	2	-	12	42	5	54	-	Yes	-	-	Std.	QFP-80
	HD6437048FW50	128 M	4																WTR	
	HD6437101F40	32 M	2	4.0-5.5	40	MTU, MMT (6)	-	Yes	2	-	8	42	5	54	-	Yes	-	-	Std.	QFP-80
	HD6437101FW40																		WTR	
SH7144	HD64F7144F50	256 F	8	3.3V	50	MTU (7)	4	Yes	4	I²C	8	51	9	74	-	Yes	Yes	Yes	Std.	QFP-112
	HD6437144F50	256 M													-	Yes	-	-		
SH7145	HD64F7145F50	256 F	8	3.3V	50	MTU (7)	4	Yes	4	I²C	8	51	9	98	-	Yes	Yes	Yes	Std.	LQFP-144
	HD6437145F50	256 M													-	Yes	-	-		
SH7065	HD64F7065AF60	256 F	4KB x2 X & Y	3.0-3.6	60	MMT, TPU (9)	4	-	3	-	8	52	8	115	-	Yes	-	-	Std.	LQFP-176
	HD6437065AF60	256 M																		

Notes
1. F = Flash; M = Mask ROM
2. MMT = Motor Management Timer;
   MTU = Multifunction Timer Unit; TPU = Timer Pulse Unit
3. DTC = Data Transfer Controller
4. Standard Temp = -20 to +75°C; I = Industrial Temp (-40 to +85°C);
   J = Industrial Temp (-40 to +85°C Extended Reliability); WTR = Wide Temp Range

Package Information

LQFP-176
26.0 ± 0.2
□24
132 · 89
133 · 88
26.0 ± 0.2
0.5
176 · 45
1 · 4 · 4
*0.22 ± 0.05
0.20 ± 0.04
⊕ 0.10 Ⓜ

QFP-112
23.2 ± 0.2
□20
84 · 57
85 · 56
23.2 ± 0.2
0.65
112 · 29
1 · 28
*0.32 ± 0.08
0.30 ± 0.06
⊕ 0.13 Ⓜ

LQFP-144
22.0 ± 0.2
□20
108 · 73
109 · 72
22.0 ± 0.2
0.5
144 · 37
1 · 36
*0.22 ± 0.05
0.20 ± 0.04
⊕ 0.08 Ⓜ

QFP-80
17.2 ± 0.2
□14
60 · 41
61 · 40
17.2 ± 0.2
0.65
80 · 21
1 · 20
*0.32 ± 0.08
0.30 ± 0.06
⊕ 0.12 Ⓜ

QFP-100
16.0 ± 0.2
□14
75 · 51
76 · 50
16.0 ± 0.2
0.5
100 · 26
1 · 25
*0.22 ± 0.05
0.20 ± 0.04
⊕ 0.08 Ⓜ

TFP-100B
16.0 ± 0.2
□14
75 · 51
76 · 50
16.0 ± 0.2
0.5
100 · 26
1 · 25
*0.22 ± 0.05
0.20 ± 0.04
⊕ 0.08 Ⓜ

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